BEACH REPLENISHMENT

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April 21, 2013

ABSTRACT

Eroding coastlines and sea level rise is a global problem. In the United States, areas that are particularly susceptible include the Mid-Atlantic and Gulf Coast regions. Beach replenishment projects and structural devices have been used to curb the effect of natural and man-made problems to protect life, property, and the coastal ecosystem. Though these projects are very beneficial to human interests, they do not take into account the damage beach replenishment causes to the coastal environment. Current policy uses costly beach replenishment projects as temporary fixes for weakened and shifting coastlines instead of a longer-term solution. Beach replenishment is a topic that is important for those that live on or near a coastline, but it has large impacts nationally as well, since these projects are subsidized by the federal government, and therefore all taxpayers. Better alternatives like managed retreat and restoring coastline to their natural and uninhabited state, though controversial, would be more cost effective and sustainable, both for human life and the environment.

Introduction

Beach replenishment is a hot topic with the media, especially with the increase in intensity and frequency of damage to coastal communities by devastating storms like Hurricane Katrina, Rita, and Sandy. When combined with sea level rise, erosion processes, and other human related activities, the potential for coastal devastation cannot be over-stated. There are many advantages and disadvantages of using beach replenishment projects to solve some of these issues.

The argument for beach replenishment has always been that the monies spent (often repeatedly spent) are worth the price because it preserves resort revenues, thus stimulating the local economy through tourism and recreation. The question is: do drastic man-made changes to the coastline harm the coastal ecosystem itself due to loss of natural wildlife habitats and "down-stream" or, more correctly "down-coast", effects of beach replenishment and protection? There are many other questions to be answered - for example, whether or not federal spending should be used to rebuild storm ravaged coastal areas. Federal regulation also comes into play – one example is the Coastal Zone Management Act (1972).

There are alternatives to beach replenishment projects such as managed retreat and implementing shorefront no-build areas on coastlines that are susceptible to substantial storm damage and erosion. This issue of man versus nature has a global effect. Many countries face this issue, not just the United States; but this examination will focus primarily on the United States. Federal spending and state regulations will be analyzed, particularly in the Mid-Atlantic and Gulf regions. Beach replenishment is an important

topic because it encompasses many different issues, but the most important feature is the preservation of our coastlines for future generations.

Coastal Erosion

Coastal erosion and flooding are now becoming a common occurrence for people who live on or near the coastline. The National Oceanic and Atmospheric Administration (NOAA) released a study that showed in 2010 about 39% of the U.S. population or 123.3 million people lived in counties that were directly on the shoreline. The amount of people living by shorelines is projected to increase by "an additional 10 million people or 8% by 2020" (NOAA, 2013). A coastline is an area where the land meets the sea or ocean, but it is worth noting that shorelines include areas where the land meets bays, estuaries, or rivers as well. Coastal erosion can be defined as the washing away of land and the removal of beach or dune sediments by natural and man-made causes (Tarbuck, 2010). Natural factors that cause coastal erosion include wind and wave action from strong coastal storms and nor'easters, tidal or ocean currents, and longshore or continental drift. Man-made factors include structures like jetties or seawalls, which can impede the natural flow of sediment, and even large, fast moving motor crafts.

Sea Level Rise

Sea level rise (SLR) is another important factor that has made coastlines susceptible to erosion problems, though there is some debate as to how much this is a result of the activities of humans. SLR, combined with the increase in intensity and frequency of storm surges, could prove to have disastrous effects on coastal regions. According to Marcus Griswold – Program Coordinator for Climate Change Adaptation at

University of Maryland Center for Environmental Science – the sea level has already risen approximately one foot (1/3 meters) within the last century (Griswold, 2013). Climate change is most certainly a factor that is associated with sea level rise – the increase in greenhouse gases such as carbon dioxide and methane has resulted in an increase in global temperatures. In turn, this has resulted in melting polar ice caps and rising ocean temperatures causing the water to expand (Gillis, 2013). This additional fresh water and expansion leads to rising sea levels, which is now encroaching on coastlines all over the world. Coastal areas that are vulnerable to SLR are also impacted by groundwater usage. Water pulled from aquifers can make the land more compact, which can cause land in the eroding area to sink (Griswold, 2013). Global and local forces are at play with SLR.

Warmer ocean temperatures could also bring about more intense weather patterns and severe storms. A recently published figure in the Proceedings of the National Academy of Sciences (PNAS) shows the trend of intense storms like Hurricane Katrina increasing more frequently in a globally warming climate:

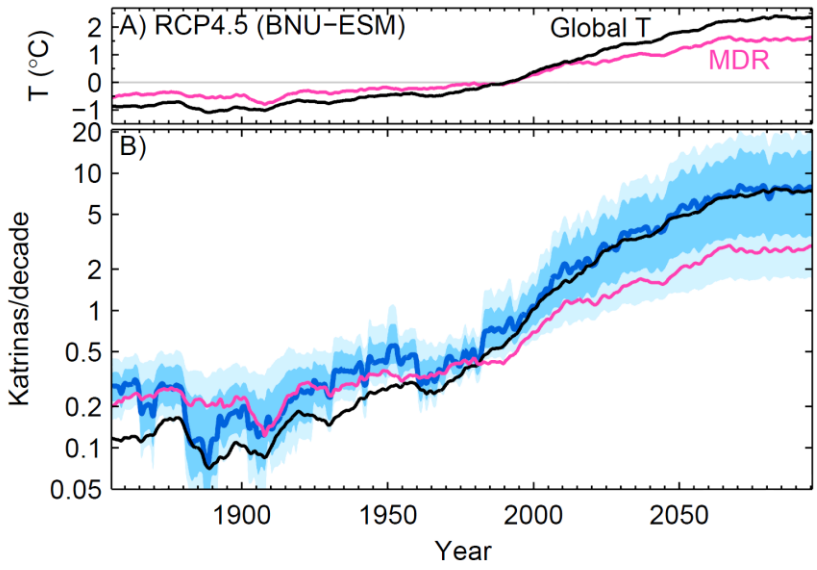

Figure 1. **Increasing Storms Potential. This figure shows the increase in frequency of storms like Hurricane Katrina in a global warming climate.**

Regions Affected by Coastal Erosion

Coastal erosion can be episodic or sporadic. It can be described as episodic in the case of a storm like Hurricane Katrina where erosion occurs for a couple of hours, or for a whole season much like El Nino in California. It can be sporadic in the sense that it can occur constantly and rapidly in one region when compared to another region where there is slow to little or no erosion, for example the Mississippi delta region compared with the rocky west coast (Stewart, 2011). Again, regions that are in danger of coastal erosion are also being threatened by SLR. This is happening now with most of the coastlines of the United States to a certain degree, though some areas are more sporadic than others. The Mid-Atlantic States are a hot spot for sea level rise (Griswold, 2013). And according to Beatley, Brower and Schwab, chronic long-term shoreline erosion problems can also be seen in the Gulf coast as well:

> This is especially a problem along the low-lying barrier island systems of the Gulf and Atlantic coasts. Average erosion rates are 6 feet per year along the Gulf and 2

> to 3 feet per year along the Atlantic. Some coastal areas may be accreting in the short term, but the general trend is in the direction of shoreline retreat. (Beatley, Brower & Schwab, 2002, pg. 68).

Other countries, especially island countries like Australia, are dealing with the effects of an eroding coastline. Examples of coastal cities dealing with eroding coastlines throughout the world as stated by coastal expert Andrew Cooper, a professor at the University of Ulster in Ireland, include "Benidorm, Torremolinos (Spain); Cannes (France); West Palm Beach, Fla.; Atlantic City, N.J, Myrtle Beach, S.C., Virginia Beach, Va.; Cancun (Mexico); and…Dubai (United Arab Emirates)" (Oskin, 2013). These "endangered beaches" and coastal regions are combating the effects of sea level rise and eroding beaches through beach replenishment projects. The risk of coastal erosion is a huge concern because of the immense risk posed to life, property, and the environment.

Beach Restoration Projects

Beach restoration projects include a variety of human activities associated with the reconstruction of a beach through beach replenishment and the rebuilding of man-made and natural structures such as buildings, roads, and sand dunes on or near a damaged coastline. Beach replenishment is one feature of a beach restoration project – it is also interchangeable with the terms sand replenishment, beach nourishment, or beach fill. Beach replenishment projects are an engineering method used to manage beaches and coastal erosion problems. These replenishment programs are often very costly and only

provide a temporary solution for sustaining a coastal area from the effects of natural and man-made problems.

Beach Replenishment Process

The process of beach replenishment includes replacing, dredging, or mining sediment (usually from an offshore location) – in this case sand, which is then used to fill in the eroding beach or coastal area. According to Committee on Beach Nourishment and Protection, approximately 95% of sand used for beach replenishment projects comes from an offshore deposit (Committee on Beach Nourishment and Protection, 1995). Sand from the offshore source is dredged, transported or piped, and then bulldozed onto a planned artificial profile from 100 to 250 feet into the water (Committee on Beach Nourishment and Protection, 1995).

***Figure 2*. Piped Sand. This figure shows sand being dredged from offshore and pipelined onto an eroding beach.**

The Marine Minerals Program of the U.S. Bureau of Ocean Management (BOEM) manages sediment dredged from the Outer Continental Shelf (OCS), which is outside of the three-mile zone for states (U.S. BOEM, 2005). Sand can also be dredged from inlets, estuaries, lagoons and adjacent beaches where sand accretes as well as acquired from quarries and flood tidal basins though this is less common because sand

from these locations is considered costly and not "beach quality" (Committee on Beach Nourishment and Protection, 1995). And most beach fill projects will place sand close to sandbars (berms) with the premise that currents will eventually move sand onto the beach.

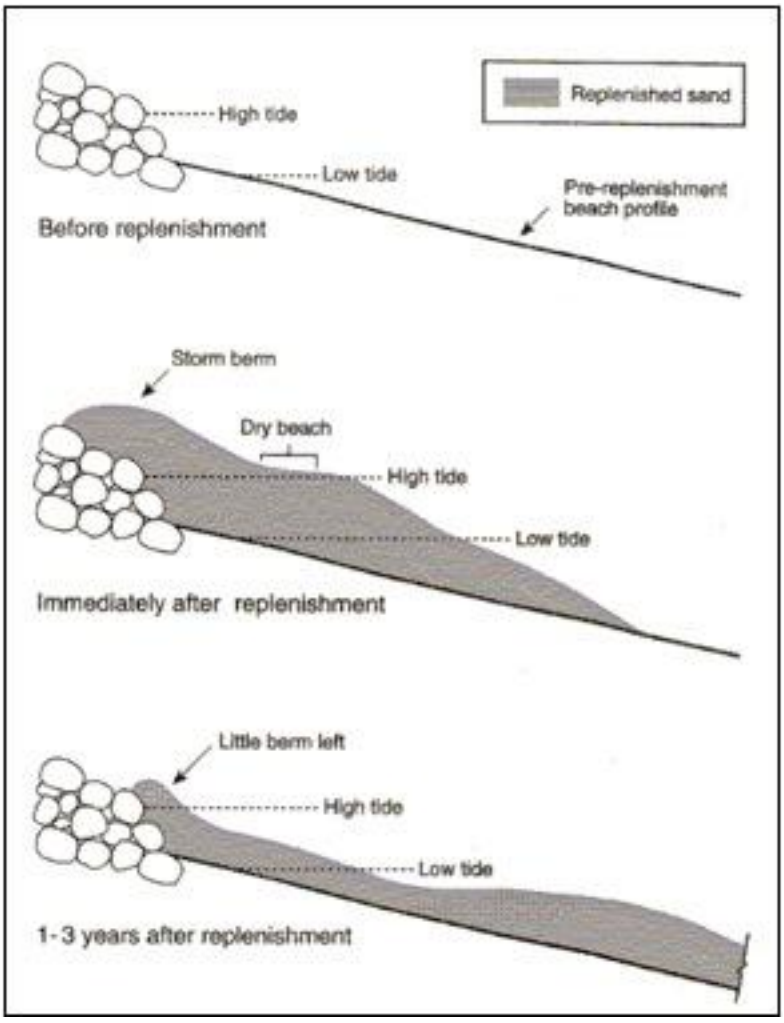

Figure 3. **Beach Replenishment. This figure shows three phases of beach - before, immediately after, and one to three years after a beach replenishment project.**

Beach fill projects are considered viable options for beach restoration because wider beaches can "reduce storm damage to coastal structures by dissipating energy across the surf zone, protecting upland structures and infrastructure from storm surges, tsunamis, and unusually high tides" (Tarbuck, 2010). This method of beach restoration is

called “soft engineering” and includes sand dune creation, sand scraping, and dune restoration.

Figure 4. **Nourished Beach. This figure shows a portion of replenished and unreplenished beach.**

The alternative of “soft engineering” for beach restoration and protection is hard structural devices like jetties, seawalls, groins, or breakwaters. Beach restoration efforts through beach replenishment projects are a means of “preserving” a beach, coastal properties, and human life, though the potential detrimental effects to the coastal environment and increased erosion should be considered.

Advantages vs. Disadvantages

Beach nourishment and structural mechanisms can help coastal areas in many positive ways but the environmental concerns are staggering. One important benefit of beach fill projects is the protection of homes, property, and infrastructure in that it can provide a buffer against storms and erosion. This can be seen in areas damaged recently by Hurricane Sandy. According to Robert Young, director of the Program for the Study of Developed Shorelines at Western Carolina University, areas that were previously

replenished and had robust dunes and wide beaches fared better compared to those without these projects (Namiotka, 2013). Protecting the coastline through these projects certainly benefits human interest through revenue generated from tourism and recreation. The widened beach can increase tourism because it allows for more "towel space," which attracts more visitors to the beach. For example, the New Jersey shores generate $35.5 billion from tourism (Parry, 2012). Habits that house different types of animals can be also be restored via beach nourishment, specifically brown pelicans and piping plovers (Committee on Beach Nourishment and Protection, 1995).

An obvious disadvantage of the project is that it can also destroy wildlife habitats by burying them under massive amounts of sand such as nesting sea turtles like Loggerhead and Leatherback species (Committee on Beach Nourishment and Protection, 1995, pg.110). Dredging of sand offshore also disturbs sea ecosystems like fish communities and reefs while altering the composition of the sand. This in turn disrupts the natural beach ecosystems and the marine food chain. Changes to the coastal environment can also negatively influence recreation and tourism because of the altered surf breaks and loss of public beach access during replenishment processes. Another concern are the costs associated with beach fill project, "…heavily developed states should expect to pay around $6 million every decade to sufficiently nourish every mile of developed coastline" (Pilkey, Trembanis & Valverde, 1999, pg. 1). These projects end up costing a significant amount of money because they need to be repeated periodically to counteract the weakened beach stability.

Federal Spending and Regulation

Federal and state governments fund most beach replenishment projects via taxes or specially created funds, some of which are overseen by coastal management programs. The federal government subsidizes about 65 percent of the cost, while the remaining costs come from state and local coffers (Parry, 2012). A study from the Coastal Research Center states "from 1986 to 2011, nearly $700 million was spent placing 80 million cubic yards of sand on about 55 percent of the New Jersey coast. Over that time, the average beach gained 4 feet of width" (Parry, 2011). This is just one example of spending for nourishment projects in the Mid-Atlantic. The chart below includes cost and spending per mile for other states including Gulf States as well:

STATE	COASTLINE MILES	RENOURISHMENT SPENDING (2012 ADJUSTED)	SPENDING PER MILE
1. New Jersey	**130**	**$1.116B**	**$8.6M**
2. Delaware	28	$216M	$7.7M
3. Maryland	31	$165M	$5.3M
4. New York	127	$567M	$4.5M
5. Virginia	112	$239M	$2.1M
6. North Carolina	301	$610M	$2.0M
7. South Carolina	187	$353M	$1.9M
8. Florida	1,350	$1.984B	$1.5M
9. Alabama	53	$71M	$1.3M
10. Mississippi	44	$56M	$1.3M

SOURCE: PROGRAM FOR THE STUDY OF DEVELOPED SHORELINES, WESTERN CAROLINA UNIVERSITY

Table 1. **Cost of Beach Fill Projects. This table shows the cost of beach fill projects in 2012 in different states. It also shows the spending of the project for every mile of coastline.**

Unfortunately, current U.S. policies on the protection of the coastline do not focus on preventative measures for coastal erosion and sea level rise. The current policy trend is accommodating or reconstructing coastal communities after disaster, as in the cases of

Hurricanes Katrina and Sandy. Mitigation grants provided by Federal Emergency Management Agency (FEMA) is a reactive strategy to prepare storm-ravaged areas for the next storm, which results in repetitive loss (Akerlof, 2013). Most of the disaster recovery funds sanctioned by the U.S. Army Corps of Engineering go back to contracts for replenishment projects. In Maryland, coastal construction plans require homes to be built four feet above sea level or two feet elevation above base flood lines but these measures do not take into account sea level rise in the future (Griswold, 2013). There are few regulations with the interest of protecting the coastal ecosystem itself – most of which are outdated. The Coastal Wetlands Planning, Protection, and Restoration Act of 1990 and the Coastal Zone Management Act of 1972 are two acts that need to be updated for the twenty-first century. In 1972, Congress passed the Coastal Zone Management Act (CZMA) with specific provisions to:

> Manage coastal development to minimize the loss of life and property caused by improper development in flood-prone, storm surge, geological hazard, and erosion-prone areas and in areas likely to be affected by or vulnerable to sea level rise, land subsidence, and saltwater intrusion, and by the destruction of natural protective features such as beaches, dunes, wetlands, and barrier islands (16U.S.C. 1451, et seq.).

These acts, coupled with additional regulation and beach restoration projects can be useful in protecting human interest while maintaining the integrity of the coastline, though they must be better utilized and brought up to date. Though many projects are not

environmentally and economically feasible, alternative means of protecting the coastline should be evaluated.

Stakeholder Agendas

Stakeholder groups can have a large influence on spending, policy, and the use of the ocean as a natural resource. There are a variety of stakeholder sectors with different policy agendas regarding conservation of ocean resources such as agriculture, construction, energy, fishing, leisure, retail, tourism, transportation, shipping and other maritime industries (IOOC, 2011). These stakeholder groups with different interests also vary by coastal region. They may also comprise of individuals interested in ocean policy and shoreline management such as those who live in developed coastal cities, surfers, and environmentalists.

Two stakeholder groups that have varying policy agendas are the Surfrider Foundation and the Ocean City Chamber of Commerce (OCCC). The Surfrider Foundation views managed retreat as the preferred option to protect the coast and to reduce the effects of sea level rise on humans. They view beach replenishment projects as counter-productive and ultimately harmful to beach ecosystems. One of the goals of the Surfrider Foundation is to get managed retreat plans implemented in order to return coastlines to their natural state and to help protect humans that would be harmed by any kind of damage resulting from higher ocean levels. Part of their strategy is to offer educational programs, such as the Respect the Beach, to get the public involved. They also lobby lawmakers and lend their name to bills that they support. The Ocean City Chamber of Commerce supports the beach replenishment projects in Ocean City, MD as it helps in bringing tourists to the beach and increased money for local businesses. They

oppose any type of managed retreat as that would result in the relocation of many businesses and would serve to decrease the amount of tourists thus reducing the amount of money spent. The goal of the OCCCC is lobby the local government in order to create a friendly environment for businesses and lobby on behalf of the multitude of businesses in the area. Their strategy for influencing policy debate is to give support to acts that serve the interests of business owners, lobby lawmakers, and shape public opinion. These stakeholders both have an interest in the issues of beach replenishment and managed retreat but fall squarely on opposite sides.

Other Alternatives

The most common method of combatting coastal erosion and sea level rise is through beach fill projects. Unfortunately, this temporary method is not realistic to sustain a stationary beach over the next 100 years with an expected three feet rise in sea level – this would require a substantial amount of sand and financial resources (Oskin, 2013). Building hard structures like sea walls to protect the beach will also have little effect because it will not allow "… the beaches room to move inland and will ultimately lead to beaches getting squeezed out as sea level rises. When the rising water reaches a protective wall between the beach and the developed land behind it, the beach is drowned" (Oskin, 2013).

But with continuing research other options for management of eroding coastlines is being explored. One such alternative is managed retreat, which involves relocating structures inland from areas that are susceptible to erosion and have little existing

development. Strategies of managed retreat programs include implementing shorefront no-build areas, rolling easements, shoreline setbacks, and zoning.

Once coastal communities are relocated further inland, another measure is to retain and expand forests, wetlands, and beaches to further protect from coastal flooding (Griswold, 2013). Fragile areas like the Mid-Atlantic and Gulf Coast states must implement adaptation plans that account for sea level rise and work to reduce greenhouse gasses by using clean energy also known as mitigation planning (Griswold, 2013). Proper planning for possibly inundated shorelines would be a better alternative than beach nourishment, which would not even be needed if developments were properly planned to give beaches the room to move in the first place (Oskin, 2013).

New Policy and Future Concerns

New policy should place a focus on maintaining and restoring natural areas, living shorelines (Akerlof, 2013) as well as practicing managed retreat in areas with constant flooding and erosion. Policies should take into account the possibility of inundated or permanently flooded coastlines. Prevention and proper planning should take precedent over reactive strategies after large coastal storms. The Marine Protection, Research, and Sanctuaries Act could also be utilized more effectively to protect wild beaches and preventing new coastal development, while repairing damaged beaches that were previously developed on. Environmental risk assessments and comprehensive cost benefit analysis must also be performed for complete evaluation of advantages and disadvantages of managed retreat.

Market Forces

Currently, coastal communities are operating in a subsidized market, where federal and state taxpayers are assuming the financial risk associated with living in these areas (Young, 2013). Even flood insurance is federally insured: "We proffer federally backed flood insurance at rates bearing no resemblance to the risks…we go in after storms and write big checks so towns can put the roads, sewers and beach sand right back where they were" (Gillis, 2013). The total amount of claims to be made to the National Flood Insurance Program by those living in distressed areas could reach $7 billion (Pilkey, 2013). The best way to encourage managed retreat is to identify areas with the greatest risk and provide them with humanitarian efforts after storms, but the choice to rebuild is their own. We should not continually federally subsidize these sensitive coastlines after each storm.

The concern here is that homes will be rebuilt by those with higher income, thus still putting life and property in danger and raising disputes over beach access. After devastating storms like Sandy, wrecked homes should be demolished and flood-prone land should be preserved permanently as undeveloped coastline. Some properties could be turned into dunes, wetlands or other natural buffers that would help protect coastal communities from ferocious storms; other parcels could be combined and turned into public parkland (Kaplan, 2013). Although managed retreat has not been a widely employed approach due mostly to political obstacles – it is starting to be implemented in several regions and is proving to be the best economic and environmental solution to the threat of rising sea levels.

Conclusion

Beach replenishment is a method used to preserve coastline infrastructure, human life, and property through replacement of sand and building of sand dunes. But this method is a costly, temporary, and repetitive process, which will not be feasible with a warming climate and the threat sea level rising. Though there are many advantages, there are even greater environmental disadvantages to the fragile coastal ecosystem. New policy must be created and old regulations updated to protect the coastline and prepare for inundation. Relocation of coastal communities further inland is one alternative to beach fill and structural projects. Though alternatives bring up many new concerns, the goal of beach preservation is better suited for success as a long-term solution.

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Figure 1. Increasing storm potential. Adapted from "Projected Atlantic Hurricane Surge Threat from Rising Sea Temperature," by A. Grinsted, J.C. Moore, & S. Jevrejeva, 2013, *PNAS,* p. 4. Copyright 2008 by the National Academy of Sciences. Reprinted with permission.

Figure 2. Piped sand. Adapted from "Barefoot Wine Beach Rescue Project." Retrieved from http://static.republic.barefootwine.com/images/beachrescue/Surfrider_Palm_Beach.jpg

Figure 3. Beach replenishment. Adapted from "Why Fill a Beach?," by Beachapedia, 2013, p. 1. Copyright 2010 by the Surfrider Foundation. Reprinted with permission.

Figure 4. Nourished beach. Adapted from "How Do You Fill a Beach?," by Beachapedia, 2013, p. 1. Copyright 2010 by the Surfrider Foundation. Reprinted with permission.

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Table 1. Cost of beach fill projects. Adapted from "Q&A: Is it worth billions to rebuild the beaches after Hurricane Sandy?," by J. Namiotka, 2013, *The Star-Ledger*, p. 1. Copyright 2013 by New Jersey On-Line LLC. Reprinted with permission.

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